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WATER QUALITY AND AQUATIC BIOLOGY, EAST FORK KAWEAH RIVER, MINERAL KING AREA CALIFORNIA

Federal Water Pollution Control Administration
San Francisco, California

August 1969

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CLEAN WATER

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
PACIFIC SOUTHWEST REGION

WATER QUALITY AND AQUATIC BIOLOGY EAST FORK KAWEAH RIVER

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WATER QUALITY AND AQUATIC BIOLOGY

EAST FORK KAWEAH RIVER
MINERAL KING AREA, CALIFORNIA

Details of illustrations in this document may be better studied on microfiche.

U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
PACIFIC SOUTHWEST REGION

August 1969

Ia

VIEW OF EAST FORK KAWEAH RIVER FROM BRIDGE TO MINERAL KING
June 1968

I-

ABSTRACT

Water quality and aquatic biological surveys were conducted during November 1967, and June and August 1968 on the East Fork Kaweah River in the Mineral King section of the Sequoia National Forest, California. The purpose of these surveys was to document the present quality of this stream prior to development of a year-round recreational area. Sampling included field measurements of temperature, dissolved oxygen, pH, and electrical conductivity; water samples were analyzed for nitrogen and phosphorus forms, iron and chlorophyll. Biological assessments included algal growth potential and enumeration and identification of planktonic and attached algae and benthic animals. The survey results document the excellent quality of the waters of the East Fork Kaweah River near Mineral King. Water quality degradation including bacteriological and eutrophic problems are expected should waste effluents reach the stream. Followup monitoring efforts are recommended following development of the recreational area.

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I. INTRODUCTION

General

The U.S. Forest Service, Department of Agriculture has approved the development of a year-round Recreational Area in the Mineral King section of the Sequoia National Forest, Tulare County, California. The development will eventually bring an estimated 1.7 million visitors to the Forest annually. The Mineral King area has been compared to the European Alps; the valley lies at an altitude of 7,900 feet surrounded by peaks that reach to the 12,400 foot level. The area is located within a four to five hour drive from the Los Angeles and San Francisco Bay Metropolitan Areas.

The site of the development and its access roads are on Federal lands including National Forest, National Park Service and Bureau of Land Management property. Thus, the effect of development and associated waste disposal and land management practices on the quality of nearby streams is of concern to the Federal Government.

Three stream surveys were performed by the Federal Water Pollution Control Administration in response to the request from the U.S. Forest Service for background data on the East Fork Kaweah River. The purpose of these surveys was to document the present water quality and aquatic life of this stream in the vicinity of the proposed recreational area. The surveys were performed in November 1967, June 1968 and August 1968 to reflect seasonal patterns. Water quality and biological sampling were performed on each date at three stations and irregularly at other selected points. A description of the surveys and the results obtained are presented in this report.

Acknowledgements

These surveys were conducted with the cooperation of the U.S. Forest Service. Field assistance was provided by Peter Wyckoff, Staff Specialist for the Mineral King Development Program. His guidance and first hand knowledge of the area were of considerable value to FWPCA field biologists conducting the surveys.

Supplemental water quality data on the East Fork Kaweah River were obtained from the U. S. Geological Survey who began a routine water quality monitoring program during 1968, and from the Calif. Department of Water Resources.

II. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The excellent quality of the waters of the East Fork Kaweah River near Mineral King is reflected in the physical, chemical and biological data gathered during the three surveys. The dissolved oxygen and pH level of the waters are compatible with requirements of cold water fishes like trout. Nutrient levels are reflective of natural humic material but are not sufficiently high to support dense aquatic growths. Aquatic plants are dominated by attached diatom growths and animals by clean water associated invertebrates such as Mayflies.

Degradation of water quality can be expected should waste effluents reach East Fork Kaweah River waters. Waste effluent additions could produce unsatisfactory bacteriological levels and eutrophication symptoms if adequate controls are not employed. Enrichment of the waters within the Mineral King area could produce nuisance growths of attached green algae such as *Ulothrix.*

Recommendations

Water quality monitoring and biological observations such as described in this report should be repeated annually to record any changes in the aquatic ecology of the East Fork Kaweah River. Follow-up surveys should be initiated after completion of any significant features of the proposed development of the Mineral King Valley. Biological surveys should employ similar techniques and be scheduled during the period between June and November. Water quality monitoring, including bacteriological measurements should be conducted during all seasons.

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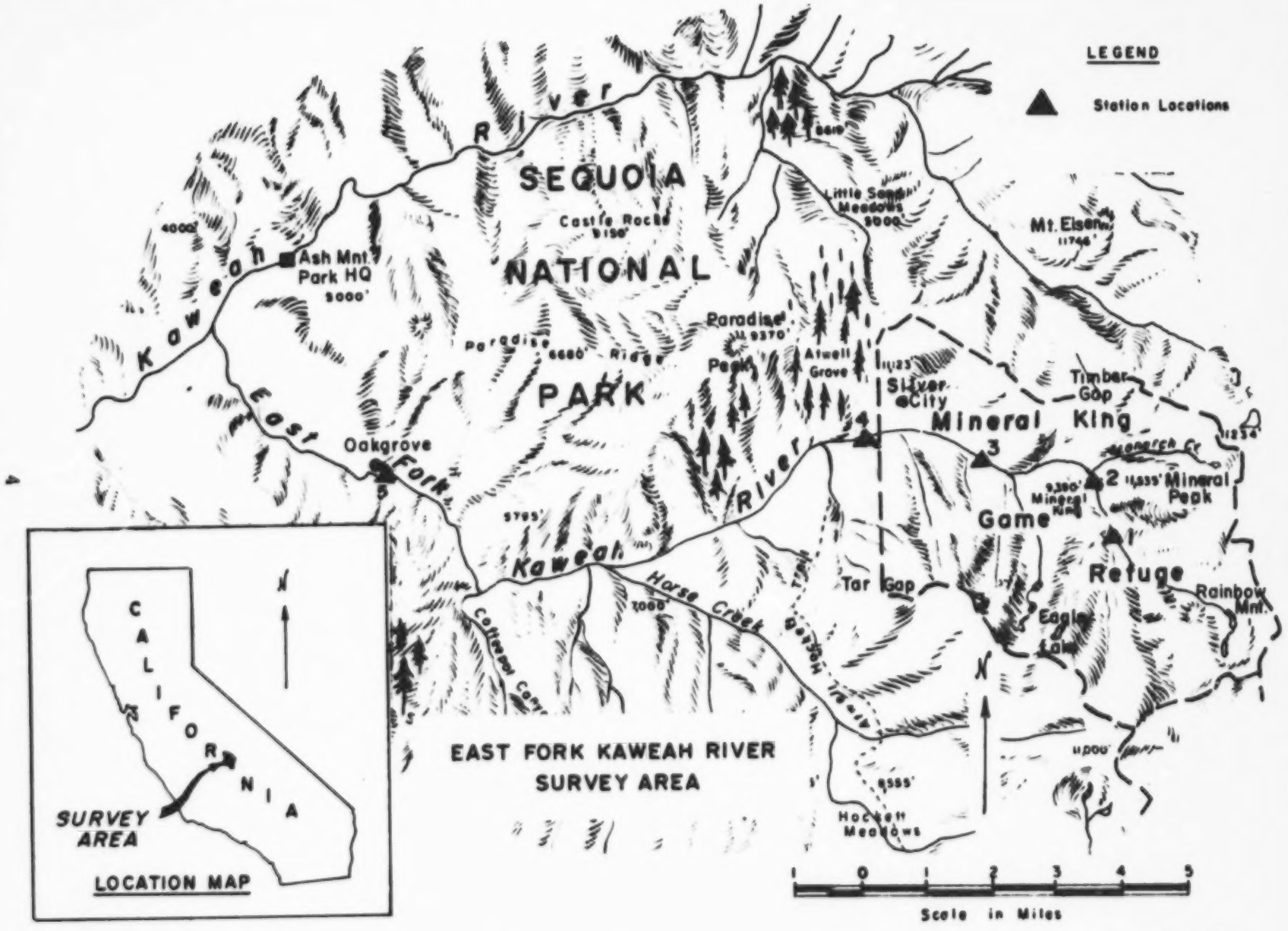

LEGEND
Station Locations
SEQUOIA
NATIONAL
PARK
Kaweah River
East Fork
Ash Mnt. Park HQ
Oakgrove
Castle Rocks
Paradise Ridge
Paradise Peak
Atwell Grove
Little Sandy Meadows
Mt. Elsen
Silver City
Mineral King
Timber Gap
Mineral Peak
Game Refuge
Tar Gap
Eagle Lake
Rainbow Mnt.
Horse Creek
Hockett Meadows
CALIFORNIA
SURVEY AREA
LOCATION MAP
EAST FORK KAWEAH RIVER
SURVEY AREA
0 1 2 3 4 5
Scale in Miles

FIGURE 1

III. STUDY DESCRIPTION

Study Area

Mineral King Valley, the source of the East Fork of the Kaweah River, is located within a Federal game refuge in the Sequoia National Forest high on the west slope of the Sierra Nevada. A map of the area (Figure 1) is on page 4. A photograph (Figure 2) of the high country surrounding the Mineral King Valley is shown below. The valley forms a drainage basin about five miles long and three miles wide. The floor of the basin drops from about 7,900 feet to 6,000 feet within this reach and is composed of unconsolidated alluvial and moraine deposits overlaying deposits of tufa in the upper valley. The slopes of the valley rise steeply against a background of peaks and ridges ranging to 12,400 feet consisting of various sedimentary, metamorphic and igineous rocks.

The valley floor is covered with a carpet of low shrubs, brush and grasses broken occasionally by a solitary lodge pole pine or stand of red fir. The most heavily forested areas are confined to the valley slopes. In the upper valley willow thickets crowd the river bed yielding gradually to groves of aspen. Further downstream, cottonwood and stands of red fir converge on the banks as the river makes its exit from Mineral King Valley.

Recreational usage was about 70,000 visitor days during 1968. Hiking, camping, fishing, and horseback riding are the chief recreational activities. Heavy snows and limited accessibility currently preclude a year-round resident population in the valley. However, several summer cabins are located below Mineral King, at Faculty Flat

Fig. 2 View of High Country, Mineral King Valley

and Silver City.

The total drainage area above the U.S. Geological Survey (USGS) sampling station on the East Fork Kaweah River near Three Rivers is 85.8 square miles. The area receives an average annual precipitation of about 36 inches. The average annual runoff ranged from 29,370 acre feet in 1961 to 213,300 acre feet in the 1967 water year. (1) Like many High Sierra streams, the river is subject to extreme seasonal flow conditions. Stream flows usually rise from January through June and then abruptly decline. The maximum and minimum flows recorded are 13,000 cfs during rain floods in December 1966 and 3.5 cfs in September 1960; the mean annual flow between 1952-1968 was 106 cfs.

Table 1

SAMPLING STATIONS

Station 1 - Picnic area north end of Aspen Flat, one mile upstream from Mineral King.

Station 2 - At bridge to Mineral King.

Station 3 - Cold Springs Camp, immediately downstream from bridge.

Station 4 - Confluence with Atwell Creek at USNPS horse corral.

Station 5 - Just upstream from Southern California Edison Station at Oakgrove.

Sampling Program

Water samples and biological collections were obtained during three stream surveys spaced to reflect seasonal differences. Survey dates were November 15,1967, June 4, 1968 and August 28, 1968.

Three stations in the East Fork Kaweah River within the Mineral King game refuge were sampled regularly on each survey; two supplemental stations located downstream from the refuge were sampled once for comparative purposes. Station locations are shown on Figure I and are described in Table 1. Photographs taken in the vicinity of several stations are shown on page 7, Figures 3 through 5.

Survey Methods

Physical and chemical measurements and biological observations and collections were designed to characterize the waters and associated aquatic life. Field measurements included air and water temperature, dissolved oxygen, pH, and electrical conductivity. Field collections included water samples for further chemical and biological testing, and biological collections including phytoplankton, attached algae, emergent vegetation, and benthic animals.

Field determinations included use of a mercury thermometer, a Beckman Model N pH meter, a Solu Bridge for conductivity and the azide

Figure 3, Station 1 vicinity, June 1968

Figure 4, Station 2 vicinity, November, 1967

Figure 5, Station 4 vicinity, June 1968

modification of the Winkler Method for dissolved oxygen. Analytical methods for nutrients include the Modified Brucine Sulfate Method for nitrate, distillation and Nesslerization for ammonia, Kjeldahl for organic nitrogen, ascorbic acid reduction for phosphorus and the orthophenantroline method for iron. A Turner fluorometer was used for measuring chlorophyll *a* flourescence following the method described by Yentsch and Menzel. (2)

Water samples collected for nutrients were preserved with mercuric chloride; samples for chlorophyll were filtered and the filtered residue preserved with $MgCO_3$, frozen and desiccated in darkness.

Algal growth assessment samples were kept cool in dark containers. Algal growth assessments were performed using a bioassay procedure described by Bain. (3) Water from each station was incubated in the FWPCA California/ Nevada Basins laboratory at Alameda. Replicated 500 ml Erlenmeyer flasks from each station were incubated at approximately 700 foot candles and 20°C for two weeks. Algal growth was monitored periodically by taking subsamples from the flasks for chlorophyll *a* measurements.

Phytoplankton, periphyton and other botanical collections were preserved with 4% formalin. Representative periphyton samples were collected through selection of uniform sized stones (~2"x3") which were then scraped and preserved for future identification at the laboratory. Phytoplankton samples (3 liters) were concentrated by settling and counted at 200x using a Sedgewick Rafter cell. A permanent slide preparation was made under higher magnification 1000x. Periphyton scrapings were homogenized and examined in a Sedgewick Rafter cell at 200x. A permanent slide was made of the sample and the diatoms were identified and counted.

Benthic macroinvertebrates (bottom living invertebrate animals from 1/64 to over 1 inch in length) were collected within and around riffle areas, where greater numbers and variety of organisms are found. Qualitative samples were obtained in November by scrubbing rocks from the stream bed within a sieve bucket of 0.75 mm openings (Figure 6A). Organisms and other residue were retained in jars, preserved in 10% formalin. Subsequent qualitative benthic sampling efforts were more rigorous than the above as described below.

Quantitative samples were obtained during the June and August surveys using a Surber Square-foot sampler, consisting of a metal frame enclosing a one-foot square area with a capture bag behind the 1.0 mm openings. The Surber Sampler was used by placing firmly and evenly on stream bottom, scrubbing rocks and rolling sand within the square-foot frame (Figure 6B), causing organisms and debris present to be carried into the bag by the current. The netted residue was then washed into a bucket and poured through a US 35 sieve.

Samples collected during June and August employed a 36" x 18" Needham type screen (.5mm openings). The screen was wedged between the sampler's knees and the stream bed

BUCKET AND BRUSH TECHNIQUE

SURBER SAMPLER TECHNIQUE

NEEDHAM SCREEN TECHNIQUE

Figure 6A, B, C

(Figure 6C). Rocks and gravel from within a 4 foot square area were rolled and brushed causing debris and organisms present to be washed down by the current and trapped on the screen. Trapped material was then washed into a large bucket of water and the screening operation repeated 8-12 times, in shallow and deep areas (2 to 36 inches), and in varied currents. See photograph (Figure 7) of biologist using screen in turbulent water. The sample bucket was then poured through a US 35 sieve (0.495 mm openings) already described. One composite screen sample was collected at each station per station visit, representing 32-48 square feet of river bottom.

Benthic collections were rinsed in a US 50 sieve (0.295 mm openings) and spread in a shallow white tray. All invertebrate organisms were picked from debris, sorted as to kind, placed in individual labeled vials of 70% alcohol, and taped together to await identification. Specimens were first identified, counted, labeled and recorded from each individual sample; then all samples were combined, grouped to taxa, and re-checked for correct identification.

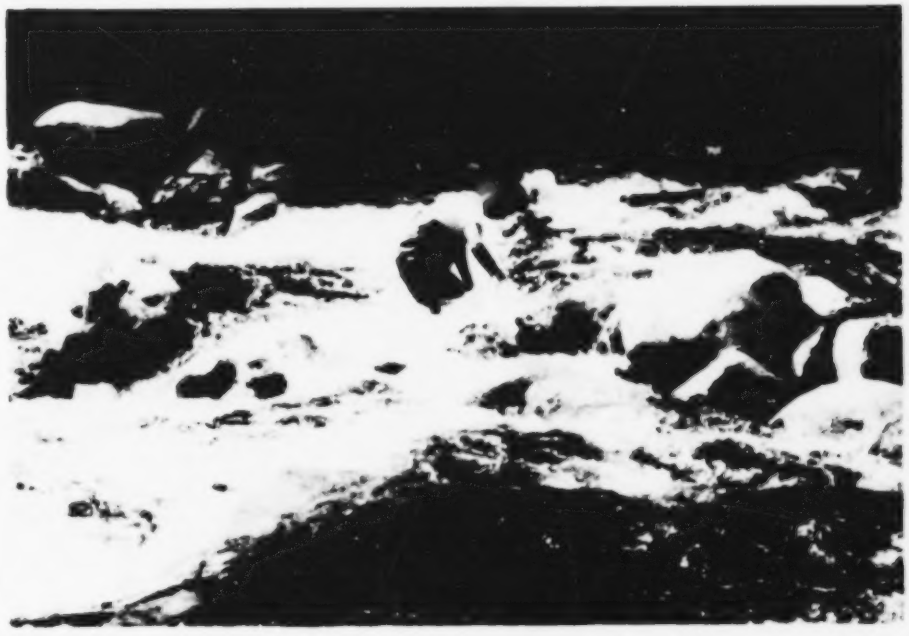


Fig. 7 Biologist Using Screen Technique at Station 3, June 1968

IV. RESULTS

Water Quality

The portion of the East Fork Kaweah River observed during these surveys was a pristine stream fed by forested slopes of the Sierra Nevada mountains. The waters were always clear, sparkling and free from detectable color, foam, or odors. Stream flow varied during the study, USGS records show stream flow at the Three Rivers Gage was 307 cfs during the June survey and 21 cfs during August. (1) Flows averaged 29 cfs in November 1967. Water quality data gathered during the three seasonal surveys are listed in Table 2 below.

TABLE 2

WATER QUALITY DATA

	Water Temp. (°C)	DO (mg/l)	pH	EC (umhos)	Nitrogen (mg/l as N) NO_3	NH_3	Org	Phosphorus (mg/l as P) Ortho	Total	Iron (mg/l)
Station 1										
Nov	4.7	9.6	7.2	165	0.09	0.2	0.4	0.02	0.04	0.015
Jun	9.0	9.0	7.8	70	0.27	0.08	0.14	0.03	0.05	0.13
Aug	11.5	8.2	7.7	125	0.06	0.08	0.22	0.01	0.01	0.03
Station 2										
Nov.	7.0	9.6	8.2	180	0.04	0.13	0.2	0.03	0.04	0.01
Jun	11.0	8.8	7.6	80	0.18	0.20	0.19	0.03	0.05	0.04
Aug.	15.0	7.6	8.0	160	--	0.08	0.27	0.01	0.01	0.03
Station 3										
Nov.	7.0	9.6	8.2	180	0.03	0.04	0.2	0.03	0.03	0.029
Jun.	12.0	8.6	7.6	85	0.10	0.08	0.14	0.04	0.05	0.08
Aug.	15.5	8.0	7.7	160	0.06	0.08	0.28	0.01	0.01	0.03
Station 4										
Jun.	13.0	9.0	7.7	65	0.08	0.11	0.14	0.02	0.05	0.06

Mineral analyses were not included as part of the FWPCA survey since these data are available from the California Department of Water Resources (DWR) and from the USGS who sampled several stations in the area during 1968. Water quality data from these two agencies gathered during mid-summer 1968 further document the excellent quality of this stream. Dissolved oxygen, pH, electrical conductivity and nutrient values are similar to those reported above; mineral analyses indicate the principal dissolved solids components of this stream are calcium, bicarbonate and silica. Chloride concentrations are extremely low, generally less than 1 mg/l. Trace element analyses confirm the iron content reported in Table 2 and indicate no excessive concentrations of other metals except possibly copper which was reported at 0.07 mg/l on one occasion by DWR. Future surveys should include copper measurements since threshold concentration of 0.02 mg/l copper has been reported for fresh water fishes. (4)

Coliform bacterial densities have also been measured as part of the USGS monitoring program. Total coliform densities are generally less than 200/100 ml within the Mineral King area; higher densities were recorded downstream particularly at Squirrel Creek near Oakgrove possibly reflecting recreational homesite developments in this area.

Aquatic Life

Aquatic life forms were typical of a high altitude Sierran stream. A variety of forms were observed, but none in any abundance that would indicate ecological imbalance. No distinct seasonal trends were apparent.

Macroscopic algal growths were not abundant at Station 1; some lettuce-like green algae (*Prasolia*) was found on snags and a few stones had limited, minor green scums consisting of a matrix of the blue green algae *Oscillatoria* mixed with the green algae, *Spirogyra* and diatoms. A short distance downstream, in the more turbulent current, such growths were not evident. Profuse growths of attached algae were observed in one small pooled area below Mineral King at Station 2 where luxuriant growths of the green algae, *Ulothrix*, covered the bottom. Station 3 was generally free from macroscopic algal growth except for *Pseudulvella* which colored some stones green with its sessile plate of microscopic cells.

Table 3 lists the diatom assemblages which are associated with river bottom rock substrates. Different periphyton species appear to predominate at the different stations, regardless of season. These may serve as indices to detect a change in water quality. Phytoplankton populations were sparse; most appear to originate from attached forms (Table 4).

TABLE 3

PER CENT ABUNDANCE OF DIATOMS FROM ROCK SUBSTRATE

	1			2			3			4	5
	NOV	JUNE	AUG	NOV	JUNE	AUG	NOV	JUNE	AUG	JUNE	AUG
Achnanthes lancenlata						X			X	X	X
" minutissima	57	59	53	70	69	26	95	59	30	56	10
Cymbella ventricosa	2	5	2	2	2	16	X	2	10	2	X
" affinis			X			1				X	
" sinnuata	12	10	13	2	23	15	X	21	15	29	2
Cocconeis placentula	5	X	12			10		X	32	2	80
Ceratoneis arcus	1	4	1	2	1	5	X	X	2		
Diatoma hiemale	9	X	2	7	X	7	1	1	1	X	
Gomphonema oliveaceum	6	7	3	6	3	4	1	5	7		4
Navicula cryptocephala	2	10	14	X	4	9	X	3		1	X
" exiqua											X
" tenelloides									X		
" tripunctata											X
" canalis	3			X							
" cinta											X
Fragilaria vaucheriae	1										
Synedra ulna	2		X			6	X		2		
" vaucheriae			1						X		X
Rhicosephenia curvata									X	X	X
Nitzschia sublinearis		X									
" amphibia		X								8	
" palea					X						
" paleacea				7			2				

X - Present at less than the 1% level.

TABLE 4

PHYTOPLANKTON COUNTS AND CHLOROPHYLL

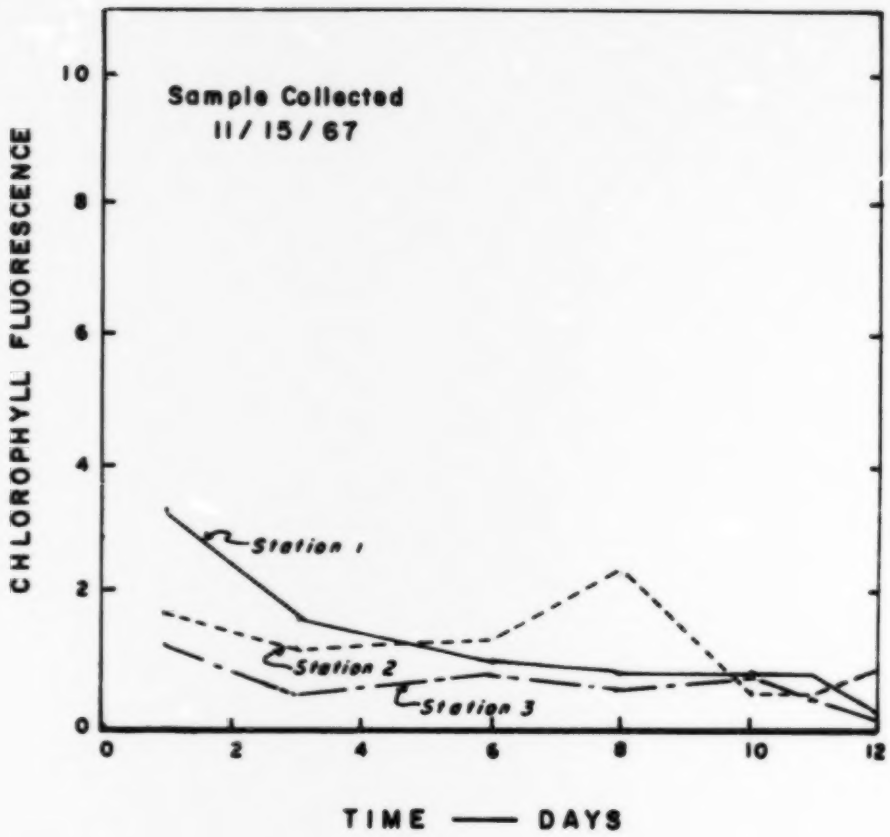
	Station 1			Station 2			Station 3		
	NOV	JUNE	AUG	NOV	JUNE	AUG	NOV	JUNE	AUG
Green									
Ankistrodesmus			850						
Ulothrix									
Spirogyra				170					
Blue Green									
Oscillatoria		170	170						
Anabaena		170							
Flagellates									
Dinobryon	850		340	170					
Diatoms									
Cyclotella		1870			1020			340	
Melosira				170					
Achnanthes	23120	15810	4420	45390	18190	9860	35360	18190	24990
Cymbella	3400	2550	850	4590	1360	5100	5780	680	16150
Diatoma				11220	1700	3910	5780	1360	4760
Ceratoneis	340	6800		1020	2550	850	2120	2210	1020
Synedra	680			1360	510	680	170	510	1360
Gomphonema			7310	170	170	9860		340	1020
Fragilaria	340								
Cocconeis			1700	170	1020	340	170	340	1870
Navicula			1700		510	3230		1020	1360
Nitzschia			1360		170	1870		170	170
Amphora			850			1870			
Total no/liter	28730	27370	19550	64330	27200	87570	49380	25160	52700
Chlorophyll A ug/liter	0.49	1.5	0.28	1.18	1.32	0.48	0.78	1.56	0.14

or report as F with equation for conversion

Results from the algal growth potential assays were negative, as perhaps might be expected from an oligotrophic stream. Chlorophyll levels declined from the levels recorded in the field and never indicated any significant algal growth. Figure 8 illustrates a typical pattern of results.

Macroinvertebrate populations were abundant and diverse. Tabulations of the 51 taxa obtained are presented in Tables 5 - 9 located in Appendix A. Dominant organisms, based on frequency of occurence, and total number of individuals are presented in Table 10 on page 36.

FIGURE 8



ALGAL GROWTH POTENTIAL
KAWEAH RIVER

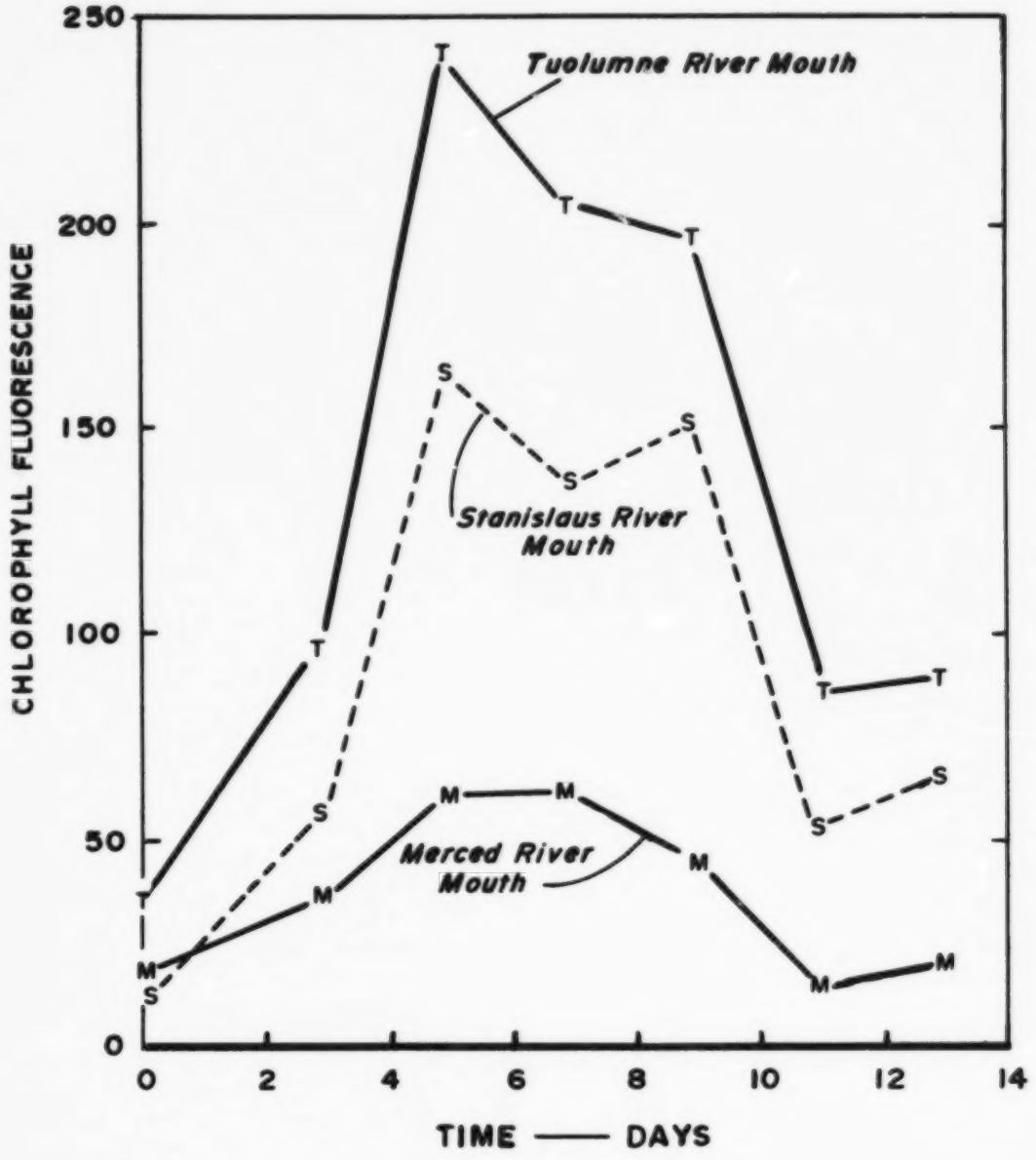
Algal growth potential assessment data from other California streams demonstrate a characteristic response to enrichment. Figures 9 and 10 illustrate results from other streams of varied quality. Figure 9 depicts the pattern of AGP from the Merced, Tuolumne and Stanislaus Rivers. The Stanislaus and Tuolumne are significantly richer in nutrients than the relatively clean Merced. Figure 10 illustrates the effect of addition of sewage treatment effluent on the AGP of the lower American River. These data help to place the East Fork Kaweah River in perspective since they illustrate the AGP pattern found in moderately enriched (American and Merced) and heavily enriched (Tuolumne and Stanislaus) streams.

Benthic animal data are often useful in water quality assessments since these animals can be classified according to their tolerance to organic wastes or other pollution. They also provide a long term record of water quality not often achievable through chemical testing. In general, the more polluted a stream, the fewer are the kinds of these organisms that survive, although the more pollution tolerant forms (such as certain midges) may be found in greater numbers. Midges were found at all stations in the East Fork Kaweah River, however the forms reported do not have ventral gills, a characteristic of pollution tolerant forms. (5)

The benthic organisms obtained by the rock scrubbing technique emphasizes rock-clinging forms such as the mayflies *Rhithrogena* and *Ironopsis*, but deemphasizes rapid moving forms such as the stonefly *Acroneuria* and mayfly *Baetis*, and excludes the burrowing forms such as crane fly larvae and segmented roundworms. The organisms obtained by the Surber Sampler technique are considered more indicative of standing crop, however because few organisms are captured this technique was of lower value in describing the benthic community. The organisms obtained by screen methods most accurately reflect the stream community, and the high rate of capture allows reliable comparisons between stations and sampling visits. Figure 11 illustrates the distribution of benthic animals for the June and August 1968 surveys when the more quantitative screen technique was employed.

The considerable variation in the species present in the East Fork Kaweah River near Mineral King is characteristic of clean, non-polluted conditions. The majority of organisms found were those which are very sensitive to organic enrichment. Aquatic plants could be stimulated by enrichment resulting from sewage discharges but some shift in the kinds of alga found would probably also result. None of the benthic animals found were known to be highly pollution tolerant.

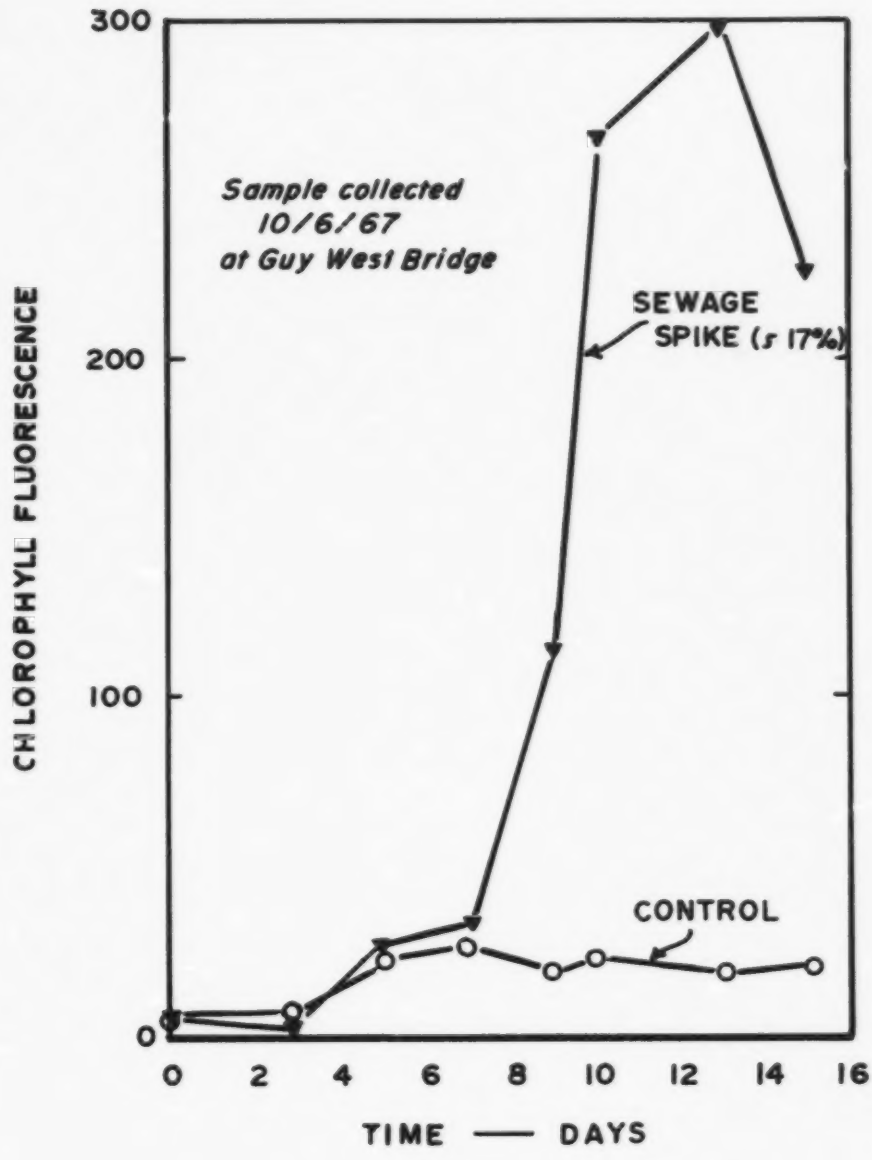
FIGURE 9



ALGAL GROWTH POTENTIAL

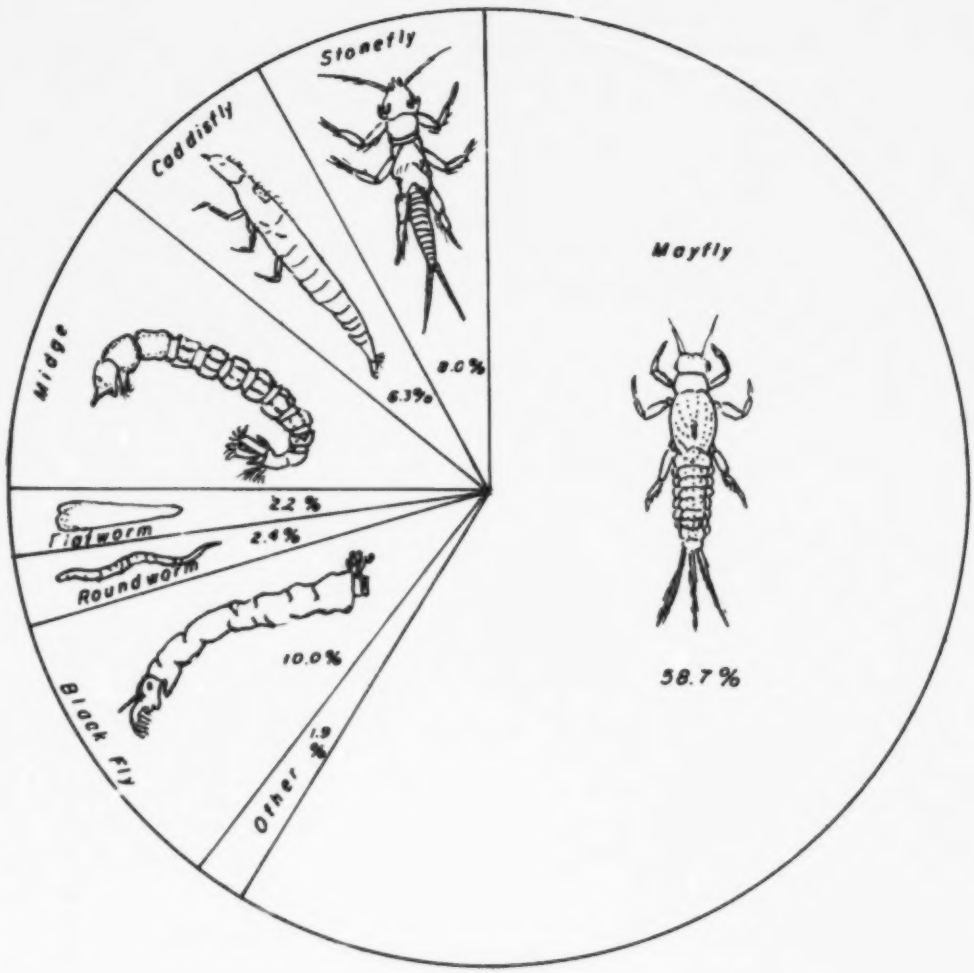
SAN JOAQUIN RIVER TRIBUTARIES

FIGURE 10



ALGAL GROWTH POTENTIAL
LOWER AMERICAN RIVER

Figure 11



Note: Distribution based on screen samples from June and August 1968 surveys.

KAWEAH RIVER STUDY

BENTHIC ANIMAL DISTRIBUTION

U.S DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
PACIFIC SOUTHWEST REGION SAN FRANCISCO, CALIF.

V. DISCUSSION

The results of the three surveys of the East Fork Kaweah River provide background data on water quality and aquatic life which are considered relevant for future surveys after the Mineral King Recreational Area is developed. Although the data record documents the conditions found additional observations and a discussion of the possible effects of the proposed developments on water quality may be helpful.

The quantity and kinds of aquatic plants found in a river reflect the physical environment as well as the fertility of the water. Floating as well as attached forms should be considered. The size and flow of the East Fork of the Kaweah precludes a significant planktonic algal community. The algae that are found grow in various microhabitats on rocks in the river bed. Some occur as a slimy coating or crust on the gravel and rocks, others take a grass-like form which appear as long green filaments waving in the current. Profuse growth of algae in the river were found only in one pooled area; there the river bed was filled with clumps of filamentous green *Ulothrix*. In general, the river appeared clean and devoid of any obvious or objectionable slimes or algal growths. The low yield of attached algae is comparable to the yield of other alpine-type west side Sierra streams that have been observed in California.

The species of diatoms found at the five stations have been tabulated for future comparisons. From these data and from the other types of algae that were found, an algal community structure characterizing this reach of the river can be tentatively proposed for the attached algae. Such a community structure or association could be described as consisting of the filamentous green *Ulothrix*, or the encrusting green *Pseudulvie11a* and the diatoms *Achnanthes minutissima* and *Cymbella sinnuata*. The green alga *Ulothrix* has been found in abundance in other California streams and in lakes and appears to thrive in waters of relatively low nutrient content.

The negative response reported for the algal growth potential (AGP) assays has been noted in other algal assays performed with oligothropic waters. While the nitrogen and phosphorus levels appear sufficient to support some growth, other nutrient elements may be limiting. Organic nitrogen values reported in Table 2 probably reflect humic materials since planktonic algal crops are so low. Algal growth assays, nutrient and other water chemistry data alone do not insure that a problem does not exist. A biological field survey is also needed to describe aquatic growths present since such growths may have stripped the waters of nutrients.

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APPENDIX A

BIOLOGY OF DOMINANT ANIMALS

MAYFLIES

Mayflies are a group of insects that have an immature (nymphal) stage that live in water. When the nymphs reach maturity, they come to the water's surface, and transform into free-flying adults which live usually no more than 24 hours.

Mayfly nymphs are the most abundant and typical insect of clean, high mountain streams. Most kinds are basic herbivores or scavengers that feed on algae, vegetable detritus or rooted aquatic vegetation; and, are in turn, a basic food source for trout and other aquatic predators. All Mayfly nymphs are intolerant to organic and toxic pollution to a greater or lesser degree, and reflect the presence of these pollutants by the reduction or absence of sensitive species, even at low concentrations. Some species of Mayflies are affected in similar manner by excessive siltation or low oxygen conditions. Therefore; any significant change in water quality due to lowered oxygen, heavy siltation, toxic substances and organic loading, should be detectable by a significant change in the kinds and relative abundance of Mayflies present.

Rhitrogena, Figure 12A, A flattened stream sprawler that attaches to rocks in swift current areas by means of claws and large, flat gills that also function as an adhesive disc. Sensitive to dissolved oxygen concentrations and siltation. Poor swimmers.

Ironopsis, Figure 12B, A flattened stream sprawler that attaches to rocks in swift current areas by means of claws and large flat gills that alos function as an adhesive disc. Sensitive to dissolved oxygen concentrations and siltation. Poor swimmer.

Cinyamula, Figure 12C, A flattened stream sprawler that attaches to rocks or rock crevices out of main current areas. Is a poor swimmer.

Ephemerella, Figure 12D, The most varied in form of all Mayflies. Occurs in a wide variety of habitats. Most of which occur in rocks or crevices out of the main current. Are awkward swimmers and omnivorous feeders.

Baetis, Figure 12E, Found wherever there is moving water, from slow to torrential, under stones, rocks, among debris or in vegetation. A good swimmer, free-ranging species that swims by rapid darts.

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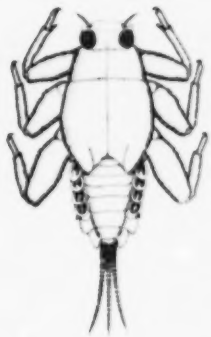
12A Rhithrogena (3X)

12B Ironopsis (2X)

12C Cinygmula (5X)



12D Ephemerella (3X)

12E Baetis (3X)

FIGURES 12A - 12E

MAYFLIES

STONEFLIES

Stoneflies are a group of insects that have an immature (nymphal) stage that lives in water. Upon reaching maturity, the nymphs migrate out of the water and transform into free-flying adults.

Most stonefly nymphs are very sensitive to the presence of organic or toxic pollutants, and all require well-aerated waters. Most stoneflies remain in the nymphal state for one year, but some require 2-4 years for full development.

Nemoura, Figure 13 A, A small, herbivorous stonefly under 10 mm long that lives in leaf drifts and feeds on decaying vegetation and algae.

Acroneuria, Figure 13B, A large carnivorous stonefly approximately 1 inch long that lives under stones in swift water areas and feeds voraciously on midge and black fly larvae.

Alloperla, Figure 13C, A small carnivorous stonefly 7-13 mm long that lives in swift water streams.

13A Nemoura (3X)

13B Acroneuria (2X)

13C Alloperla (5X)

Figures 13A - 13C

Stoneflies

CADDISFLIES

Caddisflies are a group of insects that have a long aquatic larval stage, a short aquatic pupal stage (lasting approximately 2 weeks) and then transforms into a free-flying adult which lives for approximately one month.

Most caddisfly larvae are omnivorous, feeding on algae, detritus, small aquatic animals, or each other; while others are primarily carnivorous. Many construct cases of spun-silk nets, cemented sand grains or bits of vegetation. Caddisflies are found in lakes, streams and rivers.

Rhyacophila, Figure 14, The larvae are free-living (without case), and is only found in fast flowing streams. The larvae is most abundant in fast current areas where it attaches to rocks by a pair of strong posterior legs ending in large hooks. The larvae is carnivorous, and feeds voraciously on midges, where several dozen midge larvae may be found in their alimentary tract at one time.

Figure 14 Caddisfly larvae Rhyacophila (5X)

MIDGES

Midges (sometimes called gnats) are a group of insects that have an aquatic larval and pupal stage, and then transform into a free-flying adult.

Midge larvae, Figure 15, found everywhere in streams from quiet pools to fast current areas, are most abundant in areas of heavy algae or aquatic plant growth. Most are herbivorous, feeding on algae, aquatic plants and organic detritus, but some are predaceous, feeding chiefly on other midge larvae. Their life cycle produces one or more generations a year. All arepreyed upon heavily by fish, stoneflies, and other aquatic predators, maintaining a balanced population. Pollution response ranges from very intolerant to very tolerant, depending upon the species.

Figure 15 Midge larvae Diamesa (6X)

BLACK FLIES

Black flies (sometimes called buffalo gnats) are a group of insects that have an aquatic larval and pupal stage, and then transforms into a free-flying adult. Black fly larvae and pupae occur only in flowing water, primarily in fast current areas. Larvae, Figure 16, attach to rocks by a posterior sucker ringed by hooks and feeds by filtering out plankton and detritus with large mouth brushes. Some species have a high dissolved oxygen requirement.

Adult females of most species are blood suckers, and due to toxic saliva, produces a painful bite to man and animals. Natural predation by caddisflies, midges and fish keeps this prolific organism under control, but in imbalanced streams where its predators have been reduced or eradicated, black flies have reached enormous numbers causing a nuisance condition. Generally, black fly populations are limited where there are large numbers of caddisflies.

Figure 16 Black Fly Larvae (6X)

TABLE 5

BENTHIC ANIMALS FOUND FROM ROCK SCRUBBING SAMPLES
NOVEMBER 1967

	Stations		
	#1	#2	#3
STONEFLIES (PLECOPTERA)			
Peltoperla	-	2	-
Nemoura	11	310	26
Acroneuria	-	1	1
Arcynopteryx	-	-	1
Alloperla	2	1	-
MAYFLIES (EPHEMEROPTERA)			
Rhithrogena	97	111	92
Ironopsis	287	1	19
Iron	2	-	10
Ephemerella	8	6	6
Baetis	34	55	13
Paraleptophlebia	-	-	1
CADDISFLIES (TRICHOPTERA)			
Rhyacophila	12	3	5
Parapsyche	2	5	-
Noethremma	-	1	-
Glossosoma	-	-	1
MIDGES (CHIRONOMIDAE)	127	172	138
BLACK FLIES (SIMULIIDAE)	-	45	1
FLATWORMS (PLANARIIDAE)	-	2	-
Number of Kinds	10	14	13
Total in Sample	584	715	314

TABLE 6

BENTHIC ANIMALS FOUND FROM SCREEN SAMPLES
JUNE 1968

	Stations			
	#1	#2	#3	#4
STONEFLIES (PLECOPTERA)				
Peltoperla	-	-	2	-
Nemoura	20	3	7	-
Acroneuria	-	8	7	-
Isoperia	3	-	-	-
Arcynopteryx	4	-	-	-
Alloperla	105	40	43	1
MAYFLIES (EPHEMEROPTERA)				
Rhithrogena	39	52	25	3
Ironopsis	19	33	50	116
Cinygmula	14	28	29	28
Ephemerella	31	15	51	51
Baetis	263	368	284	42
Paraleptophlebia	8	-	66	-
Ameletus	-	-	1	17
CADDISFLIES (TRICHOPTERA)				
Rhyacophila	21	32	12	-
Parapsyche	1	1	9	-
Ecclisomyia	4	-	1	-
Oligophlebodes	-	1	-	-
Neophylax	-	-	-	2
Lepidostoma	-	-	1	2
Micrasema	-	1	2	-
MIDGES (CHIRONOMIDAE)				
Diamesa	-	-	27	-
Genus A	14	5	3	5
Nanocladius	3	-	1	-
Trichocladius	5	7	6	-
Cricotopus	-	29	9	2
Brillia	-	-	1	-
Micropsectra	14	10	23	2
CRANE FLIES (TIPULIDAE)	3	4	5	-
BLACK FLIES (SIMULIIDAE)	19	4	2	-
LONG-LEGGED FLIES (DOLICHOPODIDAE)	-	-	-	1
DANCE FLIES (EMPIDIDAE)	3	-	1	3
FLATWORMS (PLANARIIDAE)	16	6	16	1
ROUNDWORMS (OLIGOCHAETA)				
[Enchytraeidae]	62	6	1	7
[Lumbricidae]	1	4	1	1
Number of kinds	23	21	29	17
Total in sample	672	657	686	284

TABLE 7

BENTHIC ANIMALS FOUND FROM SURBER SAMPLES

JUNE 1968

	Stations						
	#1		#2		#3		#4
	a	b	a	b	a	b	a
STONEFLIES (PLECOPTERA)							
Nemoura	1	1	-	-	-	-	1
Acroneuria	-	-	-	2	-	-	-
Arcynopteryx	-	1	-	-	-	-	-
Alloperla	2	4	-	1	-	-	-
MAYFLIES (EPHEMEROPTERA)							
Rhithrogena	5	16	7	10	4	7	-
Ironopsis	8	2	-	8	5	3	8
Cinygmula	2	3	2	-	2	2	14
Ephemerella	3	4	-	5	5	2	16
Baetis	29	28	10	9	16	14	4
Ameletus	-	-	-	-	-	-	1
CADDISFLIES (TRICHOPTERA)							
Rhyacophila	-	2	1	1	3	1	-
Parapsyche	2	-	-	-	2	2	-
Oligophlebodes	-	-	-	1	-	-	-
MIDGES (CHIRONOMIDAE)	-	25	-	1	6	3	6
DANCE FLIES (EMPIDIDAE)	-	2	-	-	-	2	2
FLATWORMS (PLANARIIDAE)	-	-	-	3	-	1	-
ROUNDWORMS (OLIGOCHAETA)	-	2	-	4	-	-	1
Number of Kinds	8	12	4	11	8	10	9
Number per sq ft	52	90	20	45	43	37	53

TABLE 8

BENTHIC ANIMALS FOUND FROM SCREEN SAMPLES

AUGUST 1968

	Stations			
	#1	#2	#3	#5
STONEFLIES (PLECOPTERA)				
Nemoura	53	7	10	-
Acroneuria	4	30	18	4
Isoperla	5	-	-	-
Arcynopteryx	-	2	6	23
Isogenus	9	-	-	-
Alloperla	10	-	-	-
MAYFLIES (EPHEMEROPTERA)				
Rhithrogena	113	96	118	46
Ironopsis	31	83	35	71
Heptagenia	-	-	-	6
Ephemerella	30	29	26	3
Baetis	247	127	421	62
Paraleptophlebia	6	4	3	1
Ameletus	4	1	-	-
CADDISFLIES (TRICHOPTERA)				
Rhyacophila	57	46	66	6
Parapsyche	8	3	74	-
Hydropsyche	-	-	-	6
Ecclisomyia	2	-	-	-
Lepidostoma	-	-	-	6
Glossosoma	-	-	-	21
MIDGES (CHIRONOMIDAE)				
Larsia	6	-	-	-
Apsectrotanypus	-	-	4	-
Conchapelopia	-	-	-	7
Diamesa	-	-	3	-
Prodiamesa	5	-	-	-
Genus A	2	2	3	-
Nanocladius	48	2	2	19
Trichocladius	4	11	4	6
Cricotopus	6	5	-	5
Micropsectra	141	27	50	31
Cladotanytarsus	-	-	-	24
Microtendipes	-	-	-	2
Polypedilum	-	-	-	44
DOBSONFLIES (CORYDALIDAE)	-	2	-	-
CRANE FLIES (TIPULIDAE)	-	-	15	43
BLACK FLIES (SIMULIIDAE)	9	256	371	1
LONG-LEGGED FLIES (DOLICHOPODIDAE)	-	-	1	-
DANCE FLIES (EMPIDIDAE)	4	6	2	14
RIFFLE BEETLES (ELMIDAE)	-	-	-	9
FLATWORMS (PLANARIIDAE)	58	23	15	-
ROUNDWORMS (OLIGOCHAETA)	23	6	7	-
Number of Kinds	25	22	22	24
Total in Sample	885	768	1254	460

TABLE 9
BENTHIC ANIMALS FOUND FROM SURBER SAMPLES

AUGUST 1968

	Stations									
	#1			#2			#3			#4
	a	b	c	a	b	c	a	b	c	a
STONEFLIES (PLECOPTERA)										
Nemoura	4	1	2	1	1	-	-	-	1	-
Acroneuria	-	1	-	4	5	6	2	3	1	4
Acronypteryx	-	-	-	-	-	-	-	-	1	17
Isogenus	-	1	-	-	2	-	-	-	-	-
Alloperla	1	-	5	2	-	-	-	-	-	-
MAYFLIES (EPHEMEROPTERA)										
Rhithrogena	19	63	72	70	101	116	34	40	22	-
Ironopsis	4	1	1	22	7	25	7	9	12	10
Heptagenia	-	-	-	-	-	-	-	-	-	4
Ephemerella	19	30	6	9	11	13	5	10	6	3
Baetis	7	2	5	25	39	40	2	5	1	5
CADDISFLIES (TRICHOPTERA)										
Rhyacophila	7	6	6	4	7	5	-	3	1	1
Hydropsyche	-	-	2	-	-	-	-	-	-	2
Parapsyche	1	-	-	-	1	1	2	3	8	-
Ecclisemyia	-	-	-	-	-	1	-	-	-	-
Glossosoma	-	-	-	-	-	-	1	-	-	15
AQUATIC MOTHS (PYRALIDIDAE)										
Parargyractis	-	-	1	-	-	-	-	-	-	-
MIDGES (CHIRONOMIDAE)	35	26	10	98	68	81	4	18	14	11
BITING MIDGES (HELEIDAE)	-	-	-	-	1	-	-	-	-	-
CRANE FLIES (TIPULIDAE)	-	-	-	1	1	-	-	-	-	22
BLACK FLIES (SIMULIIDAE)	1	2	1	32	6	11	5	7	4	-
DANCE FLIES (EMPIDIDAE)	5	2	3	2	-	1	-	1	-	3
SNIPE FLIES (RHAGIONIDAE)	-	-	-	-	-	-	-	-	-	1
RIFFLE BEETLES (ELMIDAE)	-	-	-	-	-	-	-	-	-	2
FLATWORMS (PLANARIIDAE)	5	2	5	1	6	7	-	-	-	-
ROUNDWORMS (OLIGOCHAETA)	13	1	19	-	3	4	-	-	-	-
Number of Kinds	13	13	14	13	15	13	9	10	11	14
Number per sq ft	121	138	138	271	259	311	62	99	71	100

TABLE 10

PERCENT OCCURRENCE OF DOMINANT BENTHIC ANIMALS

	6/4/68			8/28/68			% of all
	1	2	3	1	2	3	
STONEFLIES							
Nemoura	3.0	.5	1.0	6.0	.9	.8	2.0
Acroneuria	-	1.2	1.0	.5	3.9	1.4	1.3
Alloperia	15.6	6.1	6.3	1.2	-	-	4.9
MAYFLIES							
Rhithrogena	5.8	7.9	3.6	12.2	12.5	9.4	8.6
Ironopsis	2.8	5.0	7.3	3.5	10.8	2.8	5.4
Cinygimula	2.1	4.3	4.2	-	-	-	1.8
Ephemerella	4.6	2.3	7.4	3.4	3.8	2.1	3.9
Baetis	39.1	56.0	41.4	27.9	16.5	33.5	35.7
CADDISFLIES							
Rhyacophila	3.1	4.9	1.8	6.5	6.0	5.3	4.6
MIDGES	5.3	7.7	10.1	24.1	2.6	5.2	9.2
BLACK FLIES	2.8	.6	.3	1.0	33.3	29.6	11.3
FLATWORMS	2.4	.9	2.3	6.5	3.0	1.2	2.7
ROUNDWORMS	9.4	1.5	.4	2.6	.6	.6	2.5
total %/sample	86.6	92.8	86.7	92.8	96.9	91.3	93.9